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# Potential effect of pre-treatments on antinutritional and mineral composition of garden cress seed (Lepidium sativum)

**Umang Malhotra**
Lovely Professional University
**Manmath Sontakke** ( Manmath.28511@lpu.co.in )
Lovely Professional University

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# Abstract

This study aimed to screen an effective combination of treatment times for the processing of garden cress seeds (GCS) to enhance nutritional value. GCS was subjected to different combinations of pre-treatments, namely boiling (10 min), blanching (3 min), and soaking (12 hr) followed by roasting (2.5, 5 and 7.5 min), respectively which were compared with control sample for maximum mineral retention, especially calcium. It was found that treatment with SR 2.5 increased total protein and ash to 22.90% and 5.24%, respectively. BoR 7.5 treatment increased the fat content to 23.86%. The greatest calcium retention (378 mg/100 g) was observed when treating SR 7.5, as the ANF decreased from 458.3 to 414.5 mg/100 g for phytate and from 152.11 to 93.93 mg for oxalate /100 g. Therefore, treatment with SR 7.5 can be considered as the best pre-treatment to improve the nutritional value of GCS and reduce the anti-nutritional components.


# Introduction

Everyone in the world should have the opportunity to live a long and healthy life. However, the environment in which we live can be beneficial or detrimental to health as the environment has a major impact on our behaviour and exposure to health risks, and the opportunities presented by aging. The number and proportion of the population over the age of 60 is increasing. In year 2019 the number of people aged 60 and over was 1 billion and this number is likely to increase to 1.4 billion by 2030 and 2.1 billion by 2050 (WHO, 2022). This growth is happening at an unprecedented rate and will accelerate in the coming decades, especially in developing countries. According to National Institutes of Health, lower dietary intake of Calcium and vitamin D development of osteopenia, osteoporosis and fractures are major risk factors for the elderly age group (NIH, 2014). In addition to insufficient calcium intake, factors that lead to calcium deficiency in the elderly include reduced intestinal calcium absorption, female estrogen deficiency, long-term immobility, endocrine disorder's, low physical activity, and drug treatment (Fischer et al., 2018). Age-related bone loss occurs in both men and women when bone remodeling becomes uncoupled and changes in serum calcium require adjustment of bone turnover, as in the case of increased bone resorption due to low serum calcium (Fischer et al., 2018; Del Valle et al., 2011).

Several studies have reported that calcium intake decreases with age, with an average annual decrease of 0.21% reported after age 40 (Aloia et al., 2010). Therefore, to account for reduced calcium intake and age-related bone loss, the EAR for Indian older men and women is 1000 mg with an RDA of 1200 mg. Figure 1 Represents the recommended dietary allowance for macro and micro nutrients for Indian population aged above 60 years.

Four principal strategies, either alone or in combination can be used for correcting calcium deficiency and these include: dietary diversification or modification, supplementation, biofortification, and fortification. There are a number of neglected crops that have been used over the years for their therapeutic and medicinal properties, but their importance has diminished over time due to human ignorance. One of the most undervalued crops is GCS. To overcome the problems caused by calcium deficiency, some

inexpensive food-based methods are needed. GCS can prove beneficial for elderly group due to its high calcium content and also for children with anemia due high iron content. Garden Cress is an annual herbaceous plant which belongs to the plant order *Brassicales* and plant family *Crucifera*. It is a perennial edible herb which is a native to Egypt and South West Asia but is now grown throughout the globe (Waheeb & Makki, 2023; Yadav et al., 2018; Doke & Guha, 2014). It grows in various parts of India, North America and Europe. In India, it is mainly grown in Madhya Pradesh, Rajasthan, Gujarat, Uttar Pradesh and Maharashtra. Various regional names of GCS in different places in India are halim, holan, haliv, asali, chand shura, and many more. Table 1 includes regional names of GCS in different places in India.

Table 1
Regional names of GCS

| Regional Name | Language |
|---|---|
| Aadalu | Telugu |
| Candriki | Assamese |
| Chand Shura | Sanskrit |
| Chandasura | Oriya |
| Chansur | Hindu |
| Halim | Urdu, Bengali |
| Holan | Punjabi |
| Haliv | Marathi |
| Alian | Kashmiri |
| Allibija | Kannada |
| Allivirai | Tamil |
| Asali | Malayalam |
| Aseliyo | Gujrati |

GCS are small, oval, smooth, triangular in shape which are pointed at one end, and reddish-brown in color. When immersed in water, the seed coat swells and which gets covered with a clear, colorless mucus that has a slimy taste. The seed has a length of approximate 298 ± 3.2 μm and width 100 ± 1.9 μm (Gokavi et al., 2004). The embryo appears as an innermost structure surrounded by endosperm cells which consists of thick-walled polygonal cells. The cells of the embryo are small and polygonal in shape. Seeds are rich in both macro and micro nutrients which includes protein, fiber, omega-3 fatty acids, iron, other essential nutrients and phytochemicals. The garden cress seeds fall under the category of nuts and oilseeds food groups with high macro and micronutrients. It constitutes 30–34% carbohydrates, 25–39% of proteins, and 23–25% of fat (Al-Jasass & Al-Jasser, 2012); Gopalan et al., 2011; Gokavi et al., 2004).

The seed contains vitamins and minerals such as, calcium, iron, magnesium, thiamine, riboflavin, and niacin in the proportions 377mg, 100mg, 430mg, 0.59mg, 0.61mg, and 14.3mg per 100 g, respectively (Gopalan et al., 2011). High iron content of the seeds is useful to cure anemia. The seeds are rich in essential fatty acids like arachidic and linoleic acid (Jain & Grover, 2018). GCS also contains of some anti-nutritional factors (ANF) such as phytate, and oxalate in amounts 1037mg/100g, and 33mg/100g, respectively (Naik et al., 2020). These ANF interfere with the absorption of other nutrients but the content of these ANF can be reduced using different processing techniques such as germination or sprouting, and soaking. GCS are considered as functional food ingredient which have nutritional, phytochemical, antibacterial, toxicological, and medicinal potential. It is widely used to treat respiratory conditions such as asthma, bronchitis, and cough.

The seeds are considered a galactogen, a laxative, and are used to treat inflammation, muscle pain, and rheumatism. It is also used to regulate menstrual cycle and shows antidiabetic, laxative, cholesterol lowering fracture healing, analgesic, procoagulant and diuretic, hepatoprotective, antidiarrheal, antioxidant, blood purifier, appetite stimulator, antispasmodic and anticancer activities (Doke & Guha, 2014; Naik et al., 2020). Polyphenol content in seeds decreases the overall acceptability due to its bitter flavour and also hinders the bioavailability of minerals. The seeds act as an abortifacient for pregnant women's, thus they should avoid consuming garden cress seeds in any form (Singh & Paswan, 2017).

Since, GCS are rich in macro and micronutrients, as well as some anti-nutritional factors that limit the availability of nutrients in the seeds. A limited number of studies have been conducted analyzing the effects of treatment time combinations of processing methods on the nutritional value of garden cress seeds. Taking all points into consideration, we conducted a study analyzing the effect of processing on the nutrient composition, mineral content and anti-nutritional factors of the seeds to find the best ways to use GCS for better utilization. The research will help to popularize the seeds and their nutritional value, proving to be a good choice for addressing calcium deficiency in the elderly.

# Material And Methods

*Procurement and processing of* GCS

GCS were procured from ManHar Organics, Delhi, India and were cleaned to eliminate any extraneous materials such as dust, dirt, foreign materials and broken seeds. Different treatment-time combinations of processing methods had been applied under controlled conditions in the Food Laboratory of the Department of Food Technology and Nutrition, Lovely Professional University, Phagwara. The samples were taken in triplicate.

# Boiling

Seeds were boiled in 2 times the amount of distilled water for 10 min at 100 ± 5°C which were then sun died and followed by roasting at 150 ± 3°C for 2.5 min, 5 min, and 7.5 min in an iron vessel (Doke & Guha, 2014; Jain & Grover, 2018)

# Blanching

Seeds were blanched in 2 times the amount of distilled water for 3 min followed by immediately immersing the seeds in ice cold water which were then sun dried followed by roasting at 150 ± 3°C for 2.5 min, 5 min, and 7.5 min in an iron vessel (Kaseke et al., 2020).

# Soaking

Seeds were soaked in 2 volumes of distilled water overnight for 12hr which were sun dried and followed by roasting at 150 ± 3°C for 2.5 min, 5 min, and 7.5 min in an iron vessel (Naik et al., 2020).

Treated seeds were sun dried before roasting in the month of October, 2022 with the average temperature of 32 ± 3°C, and relative humidity was 37%. Dried, moisture-free GCS were processed into fine powder with the help of kitchen grinder. The powdered samples were packed in air tight food grade plastic bags and were kept in desiccator for further chemical analysis. Effect of various combinations of processing techniques on GCS had been studied by comparing chemical composition of raw (control) and processed seeds. Table 2 represents the samples with respective codes

Table 2
Codes with respective treatments of samples

| Sample Code | Treatments |
|---|---|
| C | Control |
| BoR 2.5 | Boiling for 10 min followed by sun drying and roasting for 2.5 min |
| BoR 5 | Boiling for 10 min followed by sun drying and roasting for 5 min |
| BoR 7.5 | Boiling for 10 min followed by sun drying and roasting for 7.5 min |
| BlR 2.5 | Blanching for 3 min followed by sun drying and roasting for 2.5 min |
| BlR 5 | Blanching for 3 min followed by sun drying and roasting for 5 min |
| BlR 7.5 | Blanching for 3 min followed by sun drying and roasting for 7.5 min |
| SR 2.5 | Soaking overnight for 12 hr followed by sun drying and roasting for 2.5 min |
| SR 5 | Soaking overnight for 12 hr followed by sun drying and roasting for 5 min |
| SR 7.5 | Soaking overnight for 12 hr followed by sun drying and roasting for 7.5 min |

# Nutritional analysis

# Proximate composition

Proximate composition which includes moisture, crude protein, crude fat, crude fibre, and ash was analysed by standard methods (AOAC, 2005). The samples were weighed in clean, dried and pre-weighed petri dishes. The moisture content of samples as determined using hot air oven at temperature of 105 ±

1°C. Protein content was calculated using Kjeldahl method which involves a three-step approach to the quantification of protein: digestion, distillation, and titration. 1 gm of the sample was added in the digestion flask with 20 ml of sulphuric acid and 2 gm of catalyst mixture (Potassium sulfate and Copper sulfate pentahydrate). Total time taken for digestion was 150 minutes at 420°C. For distillation 40 ml of 40% Sodium Hydroxide and 30 ml of 4% Boric acid was used, which resulted in the formation of the complex Ammonium Borate, which was then titrated against 0.1N Hydrochloric acid in the presence of mixed indicator and titre value was noted when light pink colour was obtained. Nitrogen factor of 5.30 was used to calculate total protein content (Swaminathan, 1974). Crude fat was extracted using Soxhlet apparatus. Round bottom flasks were washed and followed by drying in hot air oven at 100°C for 10 min. Thimbles were prepared from Whatman No. 1 filter paper and weighted moisture free samples were added. The thimbles were then placed in the Soxhlet assembly and petroleum ether with boiling point of 60–80°C was used in the fat extraction. Crude fibre determined from defatted samples which were treated with sulphuric acid, and sodium hydroxide solution. Total ash content was calculated by placing the samples in muffle furnace at 550°C for time period of 6 hours. Ellefson equation was used to calculate total carbohydrate content of the samples (Ellefson, 1993). Total energy was calculated in Kcal with the help of below mentioned equation.

$$TotalEnergy = (Crudeprotein \times 4) + (Crudefat \times 9) + (Carbohydrate \times 4)$$

# Total minerals

For the estimation of minerals particularly sodium, potassium and calcium. One gram of each sample was subjected to dry digestion in muffle furnace at 550°C for 6 hrs. The ash obtained was dissolved in 5% Nitric acid double distilled water and volume was made up to 100 ml. From the prepared 100 ml sample solution, 1 ml was taken and volume was made up to 100 ml using 5% Nitric acid double distilled water and readings were obtained using Flame photometry.

# Antinutritional factors

The downside of phytic acid is that it quickly absorbs and excretes minerals from the body because it forms insoluble chelates when it comes in contact with minerals (Arya et al., 2018). For the estimation of phytates, Thimmaiah, S. R. (2004) method was followed, sample was treated with 50ml 3% TCA with mechanical shaking for 45min. The suspension was then centrifuged at 5000 rpm for 10 minutes. 10 ml of the supernatant was transferred to 50 ml of conical flask with the addition of 4 ml of Ferric chloride solution (583 mg of $FeCl_3$ in 100 ml of 3% TCA). The flask was placed in boiling water bath for 45 min and 2 drops of 3% sodium sulphate in 3% TCA was added after 30 min. The solution was centrifuged at 5000 rpm for 10 minutes and precipitate were collected. The precipitate was washed twice by dispersing in 25ml 3% TCA, which were then placed in heat boiling water bath for 10 min. The solution was centrifuged again and precipitate were washed in hot water with addition of 3 ml of 1.5 N NaOH. Water was used to bring the volume to 30ml and solution was heated in boiling water bath for 30 min. Obtained precipitate was filtered hot through Whatman No. 2. The precipitate was washed again with 60 ml hot water and filtrate was discarded. The precipitate was dissolved in 40ml hot 3.2 N HNO, and contents were

transferred to 100ml volumetric flask. From the volumetric flask, 5ml aliquot was pipetted and transferred to another 100ml volumetric flask and diluted to approximately 70ml with distilled water and 20ml of 1.5M KSCN was added to bring the volume to 100 ml and reading was taken within 1 min at 480nm. Oxalate content was estimated using titration method against $KMnO_4$ with some modifications (Prasad Mishra et al., 2017). 1 g of sample was weighed into 250 ml of conical flask with addition of 10 ml of 6 N HCl and 190 ml of distilled water. The flasks were placed for digestion in boiling water bath for 1 hr and then filtered using Whatman No. 1 filter paper. 50 ml of filtrate was again digested in boiling water bath using 10 ml 6 N HCl. The solution was filtered and distilled water was added to make the volume up to 125 ml. 3–4 drops of methyl red indicator and few drops of concentrated ammonia was added to the solution until the colour turns to faint yellow. The solution was reheated at 90°C and filtered using Whatman No. 1 filter paper. The collected filtrate was boiled and 10 ml of 5% calcium chloride solution was added. The solution was left overnight. The solution was filtered using Whatman No. 1 filter paper and precipitate were collected. Precipitates were dissolved in distilled water and concentrated $H_2SO_4$ in the ratio 3:1. The solution was warmed at 70°C for 10 min, then titrated against 0.1 N $KMnO_4$ solution until faint pink colour. The concentration of oxalate was obtained using the following equation.

$$1ml of 0.1N KMnO_4 = 0.006303g of Oxalate$$

# Statistical Analysis

Values were taken in triplicate, and results were expressed as mean ± standard deviation. Statistical analysis of the data was performed using the Statistical Package for the Social Sciences (SPSS) version 29.0. Tukey's test was used to compare the significant differences in the means obtained after treatment-time combination of processing on GCS at significance level of $p < 0.05$.

## Results And Discussion

# Proximate composition

The effect of various treatment-time combinations of processing methods on proximate composition of garden cress seeds is listed in Table 3.

Table 3
Effect of treatment-time combination of processing on the proximate composition of GCS (%, on dry weight basis)

| Sample | Moisture % | Protein % | Fat % | Fibre % | Ash % | CHO % | Energy (kcal) |
|---|---|---|---|---|---|---|---|
| Control | 3.67 ± 0.07$^{f}$ | 22.73 ± 0.07$^{d}$ | 23.73 ± 0.06$^{b}$ | 8.33 ± 0.06$^{a}$ | 5.10 ± 0.06$^{a}$ | 40.11 | 466.93 |
| BoR 2.5 | 2.95 ± 0.06$^{e}$ | 22.09 ± 0.17$^{cd}$ | 23.76 ± 0.02$^{b}$ | 8.21 ± 0.08$^{a}$ | 4.93 ± 0.04$^{a}$ | 41.01 | 466.08 |
| BoR 5 | 2.04 ± 0.03$^{ab}$ | 21.27 ± 0.06$^{ab}$ | 23.83 ± 0.03$^{b}$ | 8.19 ± 0.06$^{a}$ | 4.62 ± 0.08$^{a}$ | 42.09 | 467.95 |
| BoR 7.5 | 1.93 ± 0.02$^{a}$ | 21.08 ± 0.07$^{a}$ | 23.86 ± 0.05$^{b}$ | 8.12 ± 0.03$^{a}$ | 4.62 ± 0.04$^{a}$ | 42.32 | 468.26 |
| BIR 2.5 | 2.27 ± 0.04$^{c}$ | 22.06 ± 0.02$^{cd}$ | 23.71 ± 0.16$^{b}$ | 8.27 ± 0.03$^{a}$ | 5.05 ± 0.03$^{a}$ | 40.91 | 465.39 |
| BIR 5 | 2.02 ± 0.05$^{ab}$ | 21.73 ± 0.02$^{bc}$ | 23.59 ± 0.08$^{ab}$ | 8.21 ± 0.09$^{a}$ | 5.02 ± 0.02$^{a}$ | 41.45 | 464.99 |
| BIR7.5 | 1.94 ± 0.05$^{ab}$ | 21.47 ± 0.02$^{ab}$ | 23.53 ± 0.06$^{ab}$ | 8.22 ± 0.03$^{a}$ | 5.01 ± 0.02$^{a}$ | 41.77 | 464.81 |
| SR2.5 | 2.55 ± 0.01$^{d}$ | 22.90 ± 0.01$^{e}$ | 23.33 ± 0.07$^{a}$ | 8.39 ± 0.06$^{a}$ | 5.24 ± 0.05$^{a}$ | 40.14 | 462.21 |
| SR 5 | 2.06 ± 0.02$^{b}$ | 22.55 ± 0.39$^{de}$ | 23.54 ± 0.26$^{ab}$ | 8.31 ± 0.05$^{a}$ | 5.19 ± 0.07$^{a}$ | 40.41 | 464.86 |
| SR 7.5 | 1.9 ± 0.01$^{a}$ | 22.19 ± 0.03$^{cd}$ | 23.61 ± 0.13$^{ab}$ | 8.30 ± 0.05$^{a}$ | 5.16 ± 0.05$^{a}$ | 40.74 | 464.21 |

Values are means ± Standard Deviations (SD) of three determinations.

Letters with different superscript show significant difference at 5% level of significance within the column

*Carbohydrate = 100 - (Protein + Fat + Fibre + Ash)

**Energy = (Protein × 4) + (Carbohydrate × 4) + (Fat × 9)

The moisture content of control seeds was analysed as 3.67 percent which is confirmed by the results obtained previously by (Jain et al., 2016), while with various treatment-time combinations the moisture content was reduced significantly due to roasting in all the treatments which results in evaporation of the moisture from the seeds which in turn favours increased shelf life (Manju & Dobha, 2022). In case of protein, observed reading showed that the raw GCS had 22.73 percent protein content which is in close agreement of the values reported by Jain et al. (2016), Gaafar et al. 2013, and Gokavi et al. (2004) which

are 22.81, 24.29, and 22.47 percent, respectively. Protein content of sample code BoR 7.5 was reported the lowest and highest for the sample code SR 5 as compared to other treatment-time combinations which was 21.08, and 23.55 percent, respectively. The marginally lower value of protein after treatment of boiling-roasting and blanching-roasting of GCS as compared to raw seeds might be a result of leaching of soluble proteins into boiling water and breakdown/denaturation of nitrogenous compounds during roasting process (Ijeh et al., 2011).

The fat content of unprocessed GCS was found to be 23.74 percent, comparable to that of Jain et al. (2016) Gopala et al. (2011), 23.40 and 24.5 percent, respectively. After soaking, the fat content dropped to 23.33 percent, the lowest reported. For seeds, a positive impression of boiling-roasting is observed, which slightly increases the fat content, since the application of dry heat is known to facilitate the release and extraction of oil from nuts and oilseeds. The crude fibre content of unprocessed GCS was 8.33 percent which is in close relation with the values obtained by various researches particularly Hassan and Rahman (2019), Jain et al. (2016), Gaafar et al. (2013), and Zia-Ul-Haq et al. (2012). Sample code SR 2.5 showed the maximum fibre content of 8.39 percent due to the formation of transparent mucilage layer throughout the seed which is polysaccharide gel with soluble dietary fibre as reported by Gokavi et al., 2004.

The values obtained for the ash content revealed that control sample contains 5.10 percent which was confirmed by results of Toliba and Mohmed (2019), and Manju & Dobha, 2022). The treatment-time combination of soaking-roasting resulted in slightly higher value of ash content. Ash content of sample code SR 2.5 was 5.24 percent which is highest among all the other treatments. From the data it can be concluded that soaking increased protein content while boiling-roasting and blanching-roasting decreased protein content. During the boiling-roasting process, the fat content increases. Fibre content increased most during soaking-roasting and decreased during boiling/roasting. Ash content increased most during soaking-roasting and decreased during boiling-roasting and blanching-roasting.

# Mineral content

The effect of various treatment-time combinations of processing methods on mineral content of GCS is listed in Table 4. Raw seeds showed 355 mg/100 g calcium, 1174.33 mg/100 g potassium and 18.2 mg/100 g sodium, which is close to the results reported by Jain et al. (2016), Gopala et al. (2011) and Gokavi et al. (2004) for calcium and Singh et al. (2015) for sodium and potassium.

Table 4
Effect of treatment-time combination of processing on the mineral content of garden cress seeds (%, on dry weight basis)

| Sample | Sodium (mg/100 g) | Potassium (mg/100 g) | Calcium (mg/100 g) |
|---|---|---|---|
| Control | 18.2 ± 0.70$^{a}$ | 1174.33 ± 4.50$^{e}$ | 355 ± 3.60$^{a}$ |
| BoR 2.5 | 21.3 ± 0.34$^{d}$ | 1153 ± 5.56$^{abcd}$ | 366.3 ± 2.08$^{abc}$ |
| BoR 5 | 22.8 ± 0.16$^{ef}$ | 1148.6 ± 9.60$^{ab}$ | 369.6 ± 4.04$^{bc}$ |
| BoR 7.5 | 23.8 ± 0.12$^{f}$ | 1145.0 ± 4.00$^{a}$ | 375 ± 4.00$^{bc}$ |
| BIR 2.5 | 20.6 ± 0.60$^{bcd}$ | 1164.6 ± 7.76$^{bcde}$ | 362.6 ± 4.50$^{ab}$ |
| BIR 5 | 20.8 ± 0.60$^{cd}$ | 1163.6 ± 4.04$^{bcde}$ | 366.7 ± 5.03$^{abc}$ |
| BIR7.5 | 21.4 ± 0.40$^{de}$ | 1151.33 ± 5.13$^{abc}$ | 374 ± 5.00$^{cd}$ |
| SR2.5 | 19.36 ± 0.23$^{ab}$ | 1168.66 ± 6.11$^{de}$ | 368.6 ± 7.02$^{bc}$ |
| SR 5 | 19.8 ± 0.70$^{bc}$ | 1165.3 ± 2.88$^{cde}$ | 371.3 ± 4.04$^{bc}$ |
| SR 7.5 | 20.4 ± 0.36$^{bcd}$ | 1162.33 ± 1.52$^{bcde}$ | 378.3 ± 3.60$^{c}$ |

Values are means ± Standard Deviations (SD) of three determinations.

Letters with different superscript show significant difference at 5% level of significance within the column

# Anti nutritional factors

The bioavailability of nutrients such as iron and calcium in food materials is usually minimized due to the presence of certain anti-nutritional factors particularly oxalate, and phytate which lead to serious nutritional deficiencies (Banerjee et al., 2015). Phytic acid has the ability to form insoluble complexes with minerals, proteins, enzymes, and starches by forming plant protein complexes (Silva & Bracarense, 2016). Oxalates are known to chelate mineral elements, rendering them unmetabolizable and inhibiting their absorption. Calcium availability in relation to dietary oxalate content is an important question in tropical diets. Regarding the availability of calcium from foods, there is consensus that the presence of oxalate affects calcium absorption (Banerjee et al., 2015). The effect of various treatment-time combinations of processing methods on anti-nutritional factors of GCS is listed in Table 5. The phytate phosphorus content of raw seeds is 458.3 mg/ 100 g, similar to that reported by Jain et al. (2016) and Gopalan et al. (2011). This value was found to have been reduced by the treatment-time combinations of processing method applied to it. In the case of treatment-time effects on oxalate values, raw seeds were found to contain 152.11 mg oxalate per 100 g which is slightly greater reported values of 134 mg/100 g and 149 mg/100 g by Jain et al. (2016) and Gopalan et al. (2011). Reduced levels of anti-nutritional

factors due to penetration into the soaking medium and cooking medium resulting in degradation at high temperature during roasting and also due to formation of insoluble complex.

Table 5
Effect of treatment-time combination of processing on the anti-nutritional factors of GCS (%, on dry weight basis)

| Sample | Phytates (mg/100g) | Oxalates (mg/100g) |
|---|---|---|
| Control | $458.3 \pm 7.00^{f}$ | $152.11 \pm 4.05^{e}$ |
| BoR 2.5 | $435.6 \pm 5.50^{bcd}$ | $120.46 \pm 4.60^{c}$ |
| BoR 5 | $429.6 \pm 3.60^{bc}$ | $113.29 \pm 6.20^{bc}$ |
| BoR 7.5 | $422.5 \pm 4.30^{ab}$ | $98.02 \pm 1.00^{a}$ |
| BIR 2.5 | $452.5 \pm 4.50^{ef}$ | $139.59 \pm 2.62^{d}$ |
| BIR 5 | $446.2 \pm 4.02^{def}$ | $125.64 \pm 2.42^{c}$ |
| BIR7.5 | $439.8 \pm 4.52^{cde}$ | $122.84 \pm 1.77^{c}$ |
| SR2.5 | $436.03 \pm 3.61^{cd}$ | $111.23 \pm 4.33^{bc}$ |
| SR 5 | $427.9 \pm 1.70^{bc}$ | $101.44 \pm 0.37^{ab}$ |
| SR 7.5 | $414.5 \pm 5.50^{a}$ | $93.93 \pm 0.83^{a}$ |
| Values are means ± Standard Deviations (SD) of three determinations. | | |
| Letters with different superscript show significant difference at 5% level of significance within the columns | | |

# Conclusion

Current research suggests that GCS can be used as a dietary supplement for the elderly because they contain high amounts of calcium. The study found that the combination of processing treatments increased the nutrient profile of GCS and significantly decreased anti-nutritional factors. For all the studied treatment-time combination of processing, blanching followed by roasting does not have any significant difference on nutritional variation of GCS. After soaking overnight for 12 hours, followed by sun drying and roasting for 7.5 minutes, calcium retention was greatest as anti-nutritional factors phytates and oxalates were minimized. Our study recommends, GCS being extremely nutrient-dense, may be a good option for older adults to take advantage of health-promoting effects.

# Declarations


### Acknowledgment

Not applicable

### Data Availability Statement

Research data are not shared.

### Conflict of Interest

The authors have no conflict of interest to declare.

### Ethical Guidelines

Ethics approval was not required for this research.

### Authors' contributions

All authors in this study have contributed in terms of research findings and discussion presented in the manuscript. Research design, analytical work and data interpretation was contributed by U. M. and M. S. The manuscript was written by U. M. and valuable inputs for improvement of research manuscript has been suggested by M. S.

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# Figures

| Nutrients | | Energy (Kcal)* | Dietary Fibre (g) | Protein (gr) | Vit-A (µg) | Thiamin $B_1$ (mg) | Riboflavin $B_2$ (mg) | Niacin (mg)# | Vit-C (mg) | Vit-$B_6$ (mg) | Folate (µg) | Vit-$B_{12}$ (µg) | Vit-D (IU) | Calcium (mg) | Magnesium (mg) | Iron (mg) | Zinc (mg) | Iodine (µg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RDAs (2020) | | | | | | | | | | | | | | | | | | |
| Men ≥60 Yrs | EAR | 1700 | - | 42.9 | 460 | 1.2 | 1.6 | - | 65 | 1.6 | 250 | 2.0 | 400 | 800 | 370 | 11 | 14 | 95 |
| | RDA | - | 32 | 54.0 | 1000 | 1.4 | 2.0 | 12 | 80 | 1.9 | 300 | 2.2 | 800† | 1200 | 440 | 19 | 17 | 150 |
| Women ≥60 Yrs | EAR | 1500 | - | 36.3 | 390 | 1.1 | 1.6 | - | 55 | 1.6 | 180 | 2.0 | 400 | 800 | 310 | 11 | 11 | 95 |
| | RDA | - | 25 | 45.7 | 840 | 1.4 | 1.9 | 9 | 65 | 1.9 | 200 | 2.2 | 800† | 1200 | 370 | 19 | 13.2 | 150 |

*: There is no RDA for Energy. The EAR is equivalent to the Estimated Energy Requirements (EER)

#: Adequate intake (AI)

**Figure 1**

Recommended dietary allowance for macro and micro nutrients for Indian population aged above 60 years

Source: Recommended dietary allowance for Indian population aged above 60 years (ICMR, 2020)